Institut für Psychologie
Lehrstuhl Allgemeine Psychologie II
Cognition · Affect · Action

Substantive Research Questions and Psychological Theory

Multinomial Modeling of the Implicit Association Test (IAT)

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SMiP | Workshop on MPT Modeling
Erdfelder, Heck, & Meissner
Frankfurt, September 15, 2018

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Agenda

1. The Implicit Association Test (IAT)

2. MPT modeling of the IAT: The ReAL model
   - 2.1 Model development
   - 2.2 Model validation
   - 2.3 Model application

3. Different models for different research questions

4. Discussion

SAMSUNG

Bild

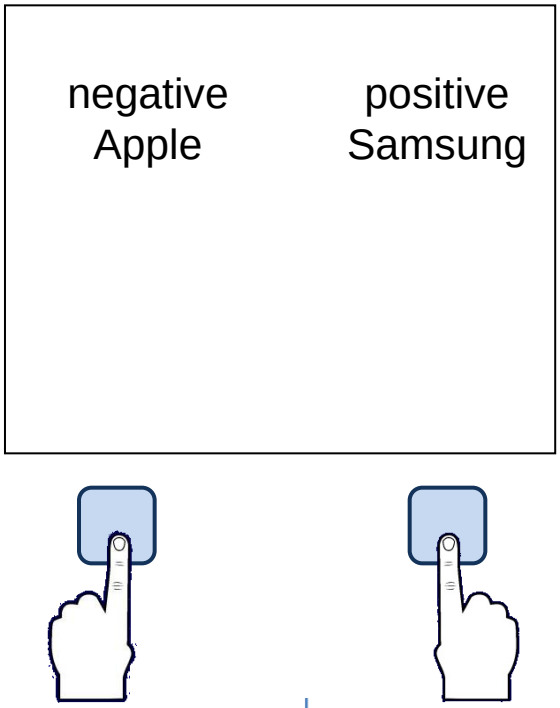
HelloKitty

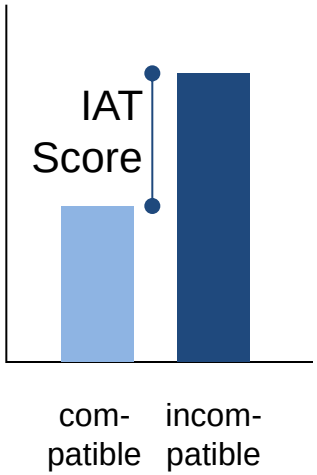
1. The Implicit Association Test (IAT)

The Implicit Association Test (IAT)

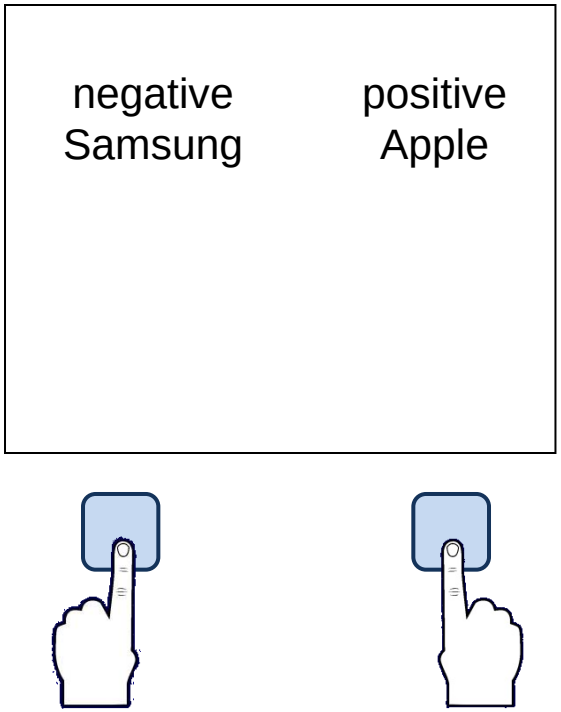
(Greenwald, McGhee, & Schwartz, 1998)

Compatible Block



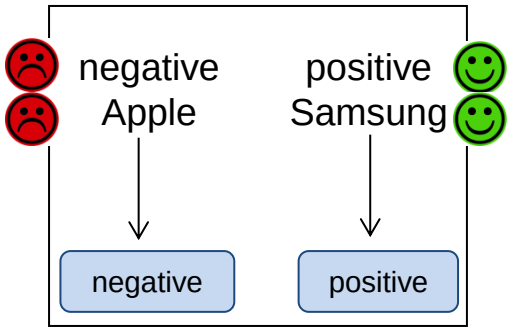


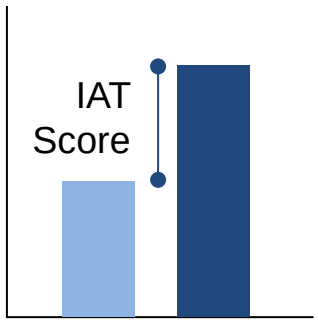
Incompatible Block



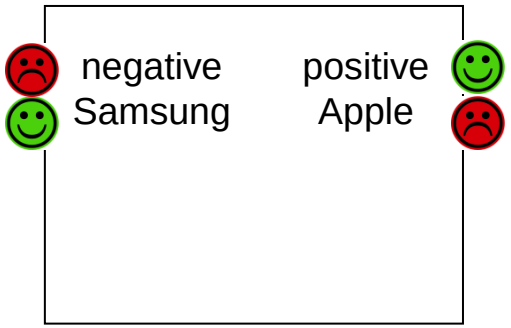
Problem 1: Recoding

Compatible Block





Incompatible Block



→ simplified task

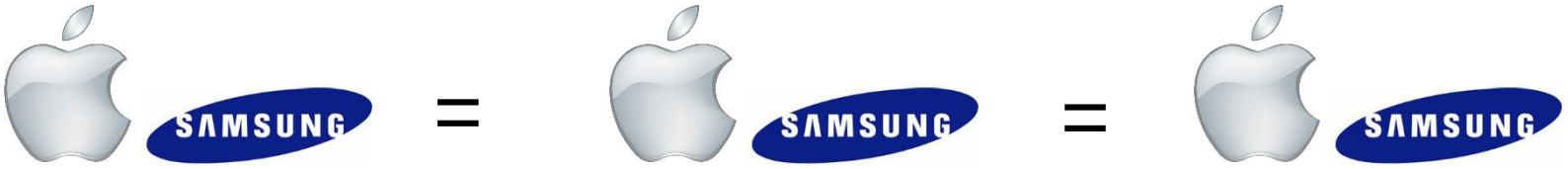
→ no simplification

Samsung:

Apple:

positive: peace, love, vacation
negative: war, murder, bomb

Problem 2: Preference Score



= 0

2. MPT Modeling of the IAT: The ReAL Model

Introducing ~~the ReAL~~ Model: 3 Steps

any new MPT

2.1 Developing the model

2.2 Validating the model

2.3 Applying the model to examine open questions

2.1 Model Development

- Response categories
- Model parameters
- Tree structure

Response Categories

	compatible block		incompatible block	
	correct	incorrect	correct	incorrect
Samsung				
Apple				
positive				
negative				

task repetition

	compatible block		incompatible block	
	correct	incorrect	correct	incorrect
Samsung				
Apple				
positive				
negative				

task switch

16 non-redundant response categories

(because $n_{errors} = n_{total} - n_{correct}$)

Model Parameters

(Meissner & Rothermund, 2013)

Recoding *Re*

Associations

A_1 A_2

Label-based identification of the response

L_1
L_2
L_3 **positive**
L_4 **negative**

Tree Structure

(Meissner & Rothermund, 2013)

- Incorporates theoretical assumptions regarding the processes, e.g.:

- Recoding determines responding…
  (e.g., Mierke & Klauer, 2001; Rothermund, Teige-Mocigemba, Gast, & Wentura, 2009)
  - in both target and attribute trials
  - only in the compatible block

- Associations determine responding…
  (e.g., Anderson, 1983; Fazio, Sanbonmatsu, Powell, & Kardes, 1986)
  - only in target trials
  - in both compatible and incompatible blocks

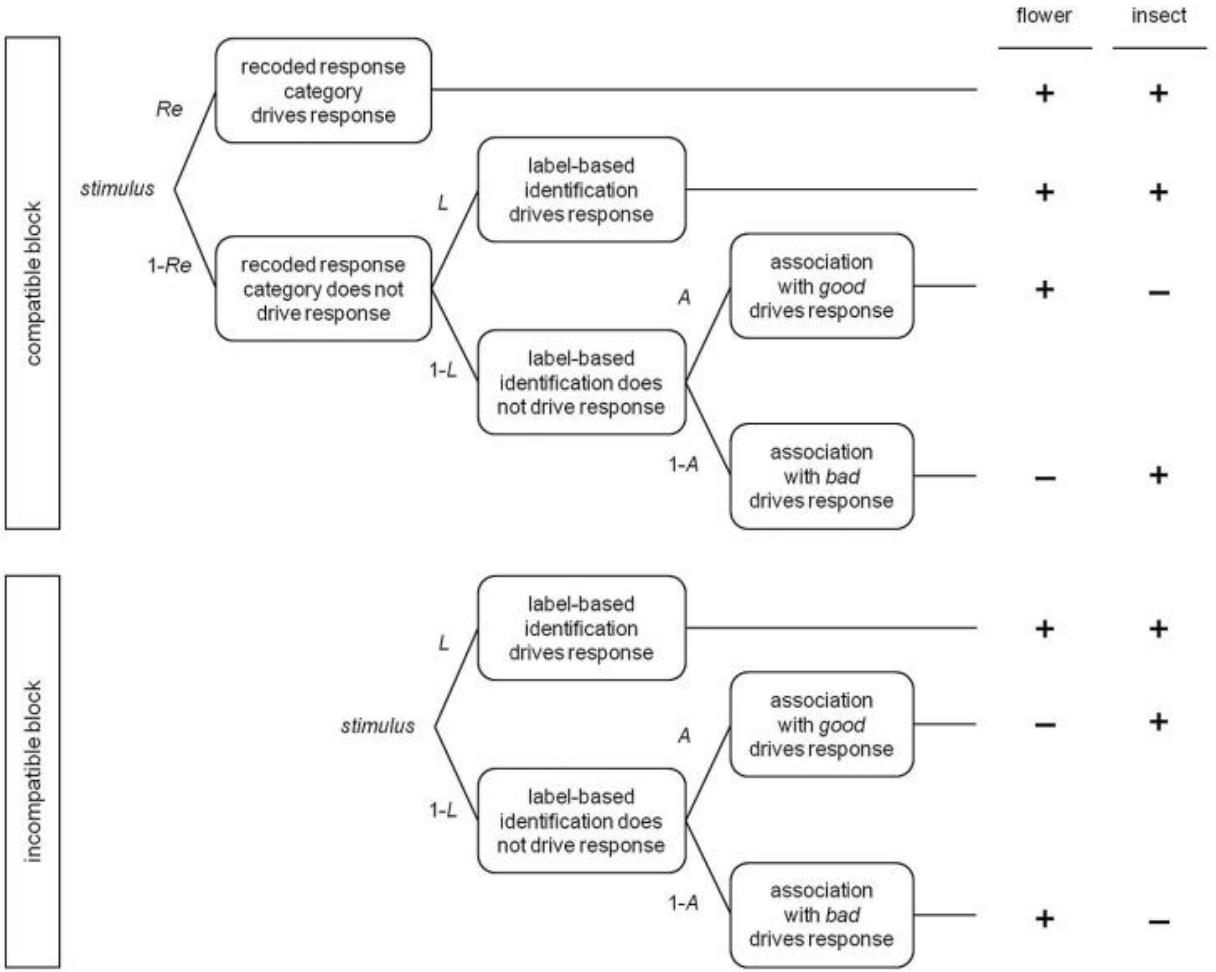


Figure 1. The ReAL model for the Implicit Association Test (IAT) for exemplars of the categories *flower* and *insect* in a flower–insect IAT. The figure illustrates an overview over the postulated interplay of recoding processes (*Re*), evaluative associations (*A*), and the label-based identification of the correct response (*L*). Dependent on the block (compatible, incompatible), a certain combination of model parameters predicts either a correct (+) or an incorrect (−) response.

Model Equations

1	1	Re*attReC*attReT
1	1	Re*attReC*(1-attReT)*L1
1	1	Re*attReC*(1-attReT)*(1-L1)*A1
1	2	Re*attReC*(1-attReT)*(1-L1)*(1-A1)
1	1	Re*(1-attReC)*L1
1	1	Re*(1-attReC)*(1-L1)*A1
1	2	Re*(1-attReC)*(1-L1)*(1-A1)
1	1	(1-Re)*L1
1	1	(1-Re)*(1-L1)*A1
1	2	(1-Re)*(1-L1)*(1-A1)
2	3	L1
2	4	(1-L1)*A1
2	3	(1-L1)*(1-A1)
3	5	Re*attReC*attReT
3	5	Re*attReC*(1-attReT)*L2
3	6	Re*attReC*(1-attReT)*(1-L2)*A2
3	5	Re*attReC*(1-attReT)*(1-L2)*(1-A2)
3	5	Re*(1-attReC)*L2
3	6	Re*(1-attReC)*(1-L2)*A2
3	5	Re*(1-attReC)*(1-L2)*(1-A2)
3	5	(1-Re)*L2
3	6	(1-Re)*(1-L2)*A2
3	5	(1-Re)*(1-L2)*(1-A2)
4	7	L2
4	7	(1-L2)*A2
4	8	(1-L2)*(1-A2)
5	9	Re*attReT
5	9	Re*(1-attReT)*L3
5	9	Re*(1-attReT)*(1-L3)*A3
5	10	Re*(1-attReT)*(1-L3)*(1-A3)
5	9	(1-Re)*L3
5	9	(1-Re)*(1-L3)*A3
5	10	(1-Re)*(1-L3)*(1-A3)
6	11	L3
6	12	(1-L3)*A3
6	11	(1-L3)*(1-A3)
7	13	Re*attReT
7	13	Re*(1-attReT)*L4
7	14	Re*(1-attReT)*(1-L4)*A4
7	13	Re*(1-attReT)*(1-L4)*(1-A4)
7	13	(1-Re)*L4
7	14	(1-Re)*(1-L4)*A4
7	13	(1-Re)*(1-L4)*(1-A4)
8	15	L4
8	15	(1-L4)*A4
8	16	(1-L4)*(1-A4)
9	17	Re*attReC
9	17	Re*(1-attReC)*L1*attL
9	17	Re*(1-attReC)*L1*(1-attL)*A1
9	18	Re*(1-attReC)*L1*(1-attL)*(1-A1)
9	17	Re*(1-attReC)*(1-L1)*A1
9	18	Re*(1-attReC)*(1-L1)*(1-A1)
9	17	(1-Re)*L1*attL
9	17	(1-Re)*L1*(1-attL)*A1
9	18	(1-Re)*L1*(1-attL)*(1-A1)
9	17	(1-Re)*(1-L1)*A1
9	18	(1-Re)*(1-L1)*(1-A1)
10	19	L1*attL
10	20	L1*(1-attL)*A1
10	19	L1*(1-attL)*(1-A1)
10	20	(1-L1)*A1
10	19	(1-L1)*(1-A1)
11	21	Re*attReC
11	21	Re*(1-attReC)*L2*attL
11	22	Re*(1-attReC)*L2*(1-attL)*A2
11	21	Re*(1-attReC)*L2*(1-attL)*(1-A2)
11	22	Re*(1-attReC)*(1-L2)*A2
11	21	Re*(1-attReC)*(1-L2)*(1-A2)
11	21	(1-Re)*L2*attL
11	22	(1-Re)*L2*(1-attL)*A2
11	21	(1-Re)*L2*(1-attL)*(1-A2)
11	22	(1-Re)*(1-L2)*A2
11	21	(1-Re)*(1-L2)*(1-A2)
12	23	L2*attL
12	23	L2*(1-attL)*A2
12	24	L2*(1-attL)*(1-A2)
12	23	(1-L2)*A2
12	24	(1-L2)*(1-A2)
13	25	Re
13	25	(1-Re)*L3*attL
13	25	(1-Re)*L3*(1-attL)*A3
13	26	(1-Re)*L3*(1-attL)*(1-A3)
13	25	(1-Re)*(1-L3)*A3
13	26	(1-Re)*(1-L3)*(1-A3)
14	27	L3*attL
14	28	L3*(1-attL)*A3
14	27	L3*(1-attL)*(1-A3)
14	28	(1-L3)*A3
14	27	(1-L3)*(1-A3)
15	29	Re
15	29	(1-Re)*L4*attL
15	30	(1-Re)*L4*(1-attL)*A4
15	29	(1-Re)*L4*(1-attL)*(1-A4)
15	30	(1-Re)*(1-L4)*A4
15	29	(1-Re)*(1-L4)*(1-A4)
16	31	L4*attL
16	31	L4*(1-attL)*A4
16	32	L4*(1-attL)*(1-A4)
16	31	(1-L4)*A4
16	32	(1-L4)*(1-A4)

ReAL model eqn file

The ReAL model for the IAT

(Meissner & Rothermund, 2013)

- 7 core parameters

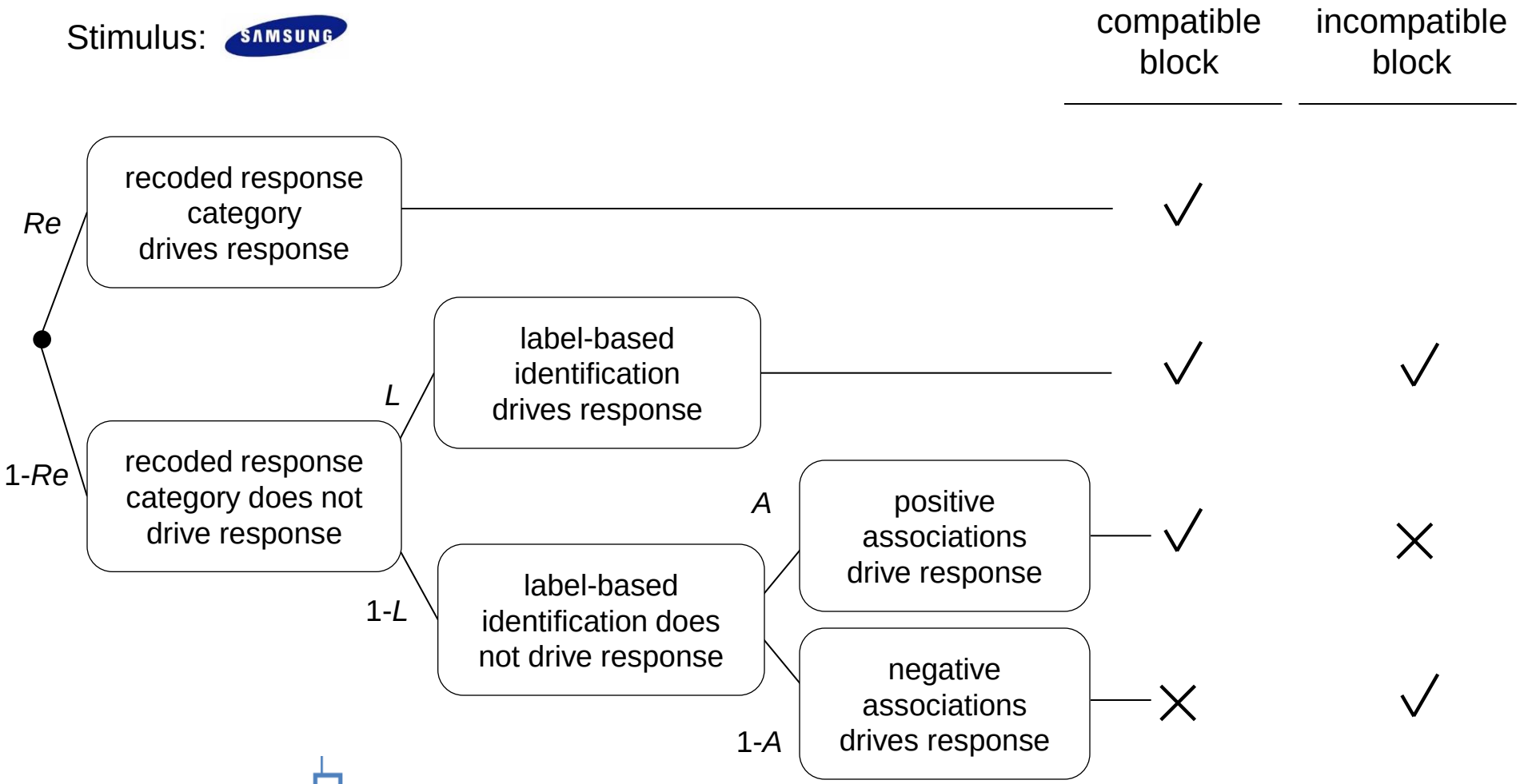
		Test against
– recoding	(*Re*)	0
– associations	(A_1, A_2)	.5
– label-based discrimination	(L_1, L_2, L_3, L_4)	0

- 3 technical parameters (*attL, attReC, attReT)*

➡ 10 parameters

➡ 16 independent response categories
i.e., *df* = 6 for model fit test

Tree Structure (simplified)



Pilot Study: Flower-Insect IAT

- Targets: **flower** (e.g., “rose”, “tulip”) vs. **insect** (e.g., “maggot”, “wasp”)
- Attributes: **good** (e.g., “holiday”, “peace”) vs. **bad** (e.g., “fear”, “pain”)

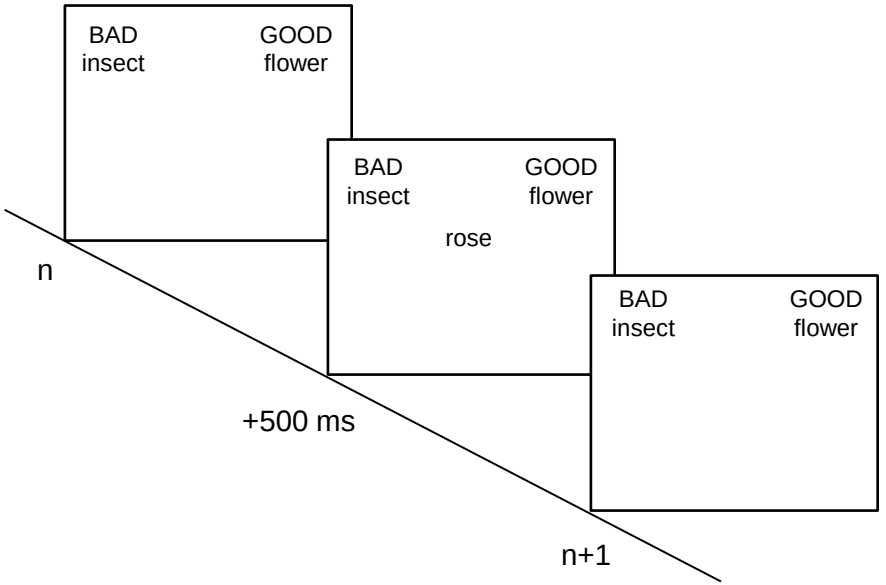
- 160 trials per participant
- *N* = 18

Model Fit?

Re, *A* & *L* sign.?

$A_{flower} > .5$?

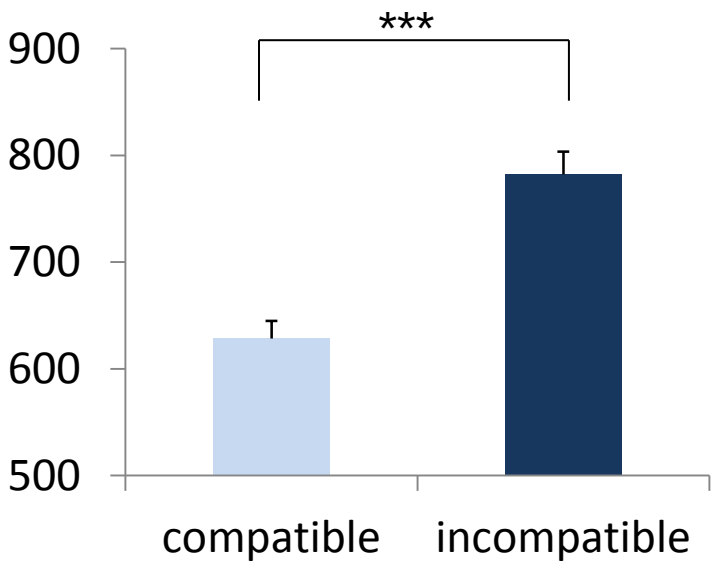
$A_{insect} < .5$?



Pilot Study: Flower-Insect IAT

< 8% errors

Analysis of RTs



Strong RT effects

Model analysis

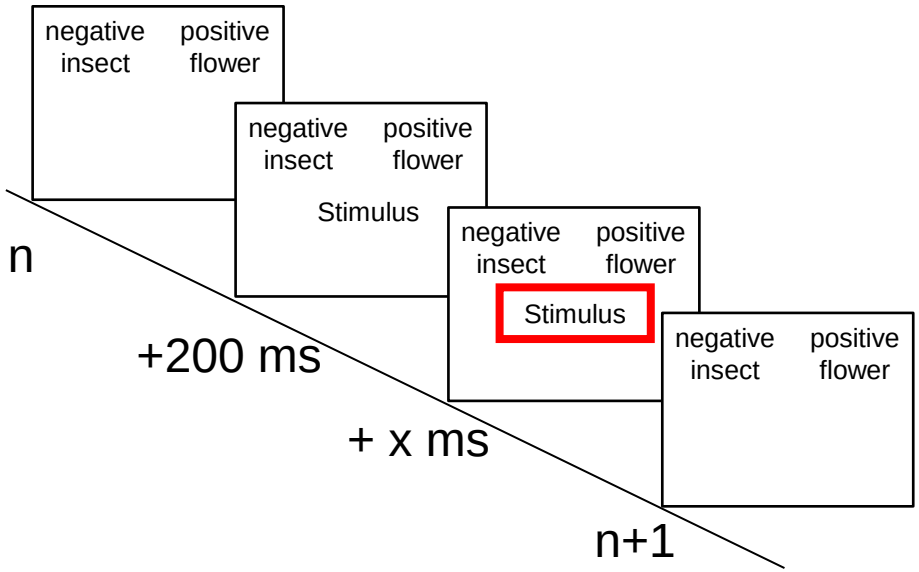
(complete pooling)

Parameter	Estimate	95% CI	
L_{flower}	.86***	[.80, .93]	
L_{insect}	.84***	[.77, .91]	
L_{good}	.91***	[.86, .96]	
L_{bad}	.84***	[.78, .90]	
Re	.34*	[.09, .60]	
A_{flower}	.60	[.40, .79]	$\neq^{\dagger}$
A_{insect}	.37†	[.18, .56]	

Note: $G^2(6) = 6.00$, $p = .423$

†$p < .10$; *$p < .05$; **$p < .01$; ***$p < .001$.

Transferring RT effects into error rates



1st Block Pair

Compatible Block
Incompatible Block

2nd Block Pair

Compatible Block
Incompatible Block

…

6th Block Pair

Compatible Block
Incompatible Block

ReAL IAT Procedure

- response deadline
- more trials (i.e., more blocks): 320 trials per participant

↳ individual estimates

2.2 Model Validation

Model Validation

- It is not sufficient…
  - …to come up with a model structure
  - …to label parameters according to some important processes
  - …and to check model fit.

- Additionally, test whether the parameters are valid measures of those processes.
  - Make use of **established** manipulations. You should be as sure as possible that these manipulations tap into one and only one process.
  - Do so **before** applying the model to new research questions.
  - Be patient.

> *„Validating the process parameters typically requires a careful and costly experimental program in which convergent and discriminant validity are established for each parameter“* (Klauer, Stahl, & Voss, 2012)

Model Validation

- For the ReAL model, we did 7 validation studies.
- Selective influence studies

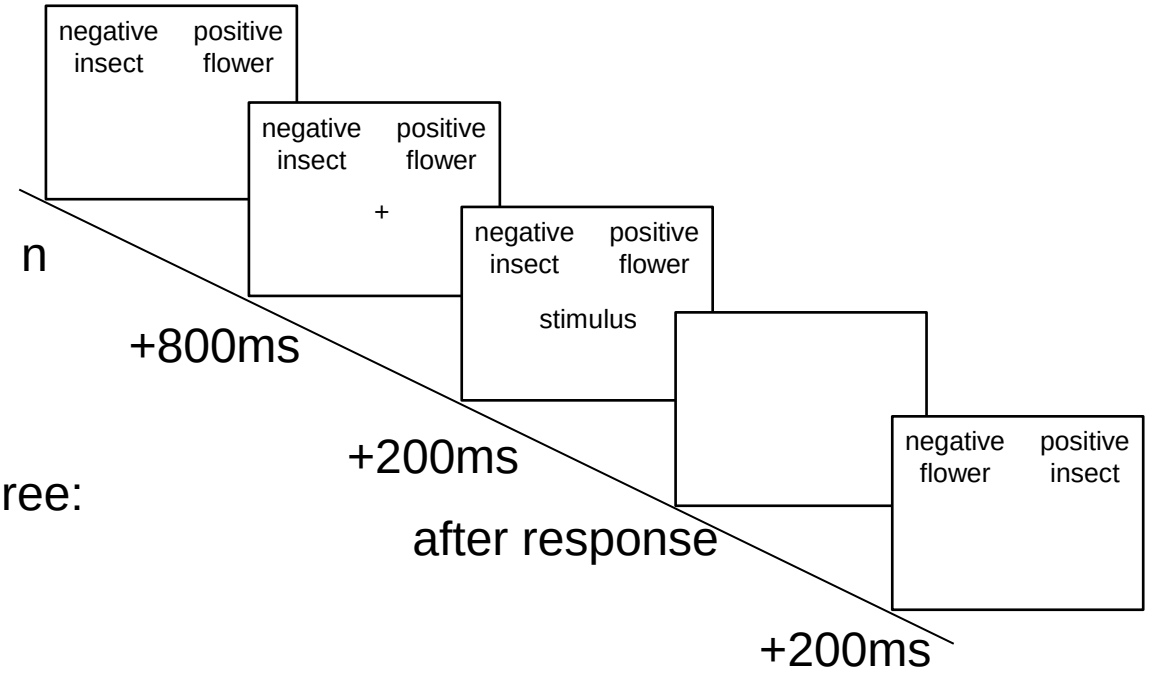
  Experimental manipulations addressing a specific process should affect only parameters reflecting this process.
  - Study 1 (*Re*)
  - Study 2 (*A*)
- Correlative studies

  Parameters should be valid measures of inter-individual differences.
  - Study 3 (convergent validity of *A*)
  - Study 4 (predictive validity of *A*)

Study 1: Manipulating Recoding

(Meissner & Rothermund, 2013)

- Recoding is reduced if block structure is dropped
  - IAT Recoding-Free (Rothermund, Teige-Mocigemba, Gast, & Wentura, 2009)
  - Single-Block IAT (Teige-Mocigemba, Klauer, & Rothermund, 2008)



e.g., IAT Recoding-Free:

Study 1: Manipulating Recoding

(Meissner & Rothermund, 2013)

- Recoding is reduced if block structure is dropped
  - IAT Recoding-Free (Rothermund, Teige-Mocigemba, Gast, & Wentura, 2009)
  - Single-Block IAT (Teige-Mocigemba, Klauer, & Rothermund, 2008)

- Experimental manipulation of *Re*
  - Control group: Standard IAT (N = 40)
  - Experimental group: IAT-RF or SB-IAT (N = 80)

  (Flower-insect IAT with response deadline)

Study 1: Manipulating Recoding

(Meissner & Rothermund, 2013)

Control Group

Parameter	Mean Estimate	SE	
Re	.46***	.04	>***
A_{flower}	.64***	.03	=
A_{insect}	.38***	.03	=
L_{flower}	.58***	.03	>***
L_{insect}	.54***	.03	>***
L_{good}	.64***	.03	=
L_{bad}	.65***	.03	=

Note: median $G^2(6) = 8.90$, $p = .179$

Experimental Group

Parameter	Mean Estimate	SE
Re	.30***	.02
A_{flower}	.60***	.02
A_{insect}	.40***	.02
L_{flower}	.38***	.02
L_{insect}	.37***	.02
L_{good}	.65***	.02
L_{bad}	.70***	.02

Note: median $G^2(6) = 7.47$, $p = .280$

†$p < .10$; *$p < .05$; **$p < .01$; ***$p < .001$.

Study 2: Manipulating Associations

(Meissner & Rothermund, 2013)

- Associations can be formed by a short story providing positive/negative information about unknown groups
  (e.g., Gregg, Seibt, & Banaji, 2006)

- Experimental manipulation of *A*
  - Faked article about two fictive soccer teams: „Blauheim“ and „Rundstedt“
  - Described clearly positive vs. negative (counterbalanced, i.e., Blauheim=positive & Rundstedt=negative, or vice versa)
  - Afterwards, Blauheim-Rundstedt IAT (with response deadline)
  - *N* = 40

Study 2: Manipulating Associations

(Meissner & Rothermund, 2013)

	Parameter	Mean Estimate	SE
	Re	.36*	.04
≠***	$A_{positiveTeam}$	.48	.02
	$A_{negativeTeam}$	.39***	.02
	$L_{positiveTeam}$	.32***	.03
	$L_{negativeTeam}$	.41***	.03
	L_{good}	.70***	.03
	L_{bad}	.64***	.03

Note: median $G^2(6) = 7.90$, $p = .246$

†$p < .10$; *$p < .05$; **$p < .01$; ***$p < .001$.

Study 3: Convergent Validity

(Meissner & Rothermund, unpublished)

negative	positive
Jane Doe	John Doe

negative	positive
John Doe	Jane Doe

- *N* = 65
- Self-esteem IAT
  - self vs. favorite other
  - idiographic stimuli
- Criterion: Name Letter Task (NLT)

- Main hypotheses:
  - Both $A_{self} > .5$ and $A_{favoriteOther} > .5$
  - Significant correlation of and A_{self} and the NLT score

Study 3: Convergent Validity

(Meissner & Rothermund, unpublished)

Parameter	Mean Estimate	SE
Re	.28*	.04
A_{self}	.55*	.02
$A_{favoriteOther}$	.53†	.02
L_{self}	.66***	.02
$L_{favoriteOther}$	.63***	.02
L_{good}	.51***	.03
L_{bad}	.59***	.03

Note: median $G^2(6) = 7.09$, $p = .313$
†$p < .10$; *$p < .05$; **$p < .01$; ***$p < .001$.

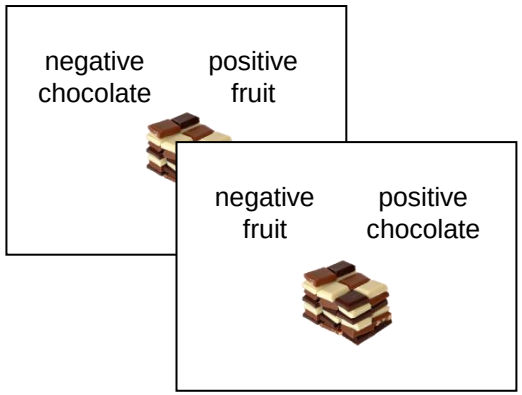
Convergent Validity of A_{self}:

$r = .25$*

Study 4: Predictive Validity

(Meissner & Rothermund, 2013)

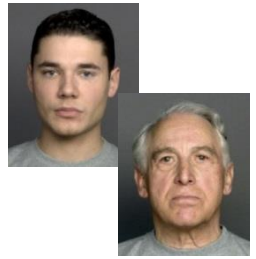
- N = 85
- fruit-chocolate IAT and consumption behavior
  (amount of chocolate eaten while watching a short movie clip)



$A_{chocolate}$ → r = .24*

Model Validation: Summary

(Meissner & Rothermund, 2013; Meissner & Rothermund, unpublished)



*A*ssociations

- Reflect the direction and the strength of spontaneous evaluations
- In different attitude domains…

- Convergent

and predictive validity

(outperforming the IAT score)

Model Validation: Summary

(Meissner & Rothermund, 2013)

*L*abel-based identification of the response

- reflects the difficulty of the categorization task
  (using pictures vs. words as stimuli)
- depends on cognitive ressources
  (different response deadlines)

*Re*coding

- Is reduced if recoding strategies are minimized
  (Single-Block IAT, IAT Recoding-Free)
- Correlates with a marker of recoding processes
  (the switch-cost effect in the IAT)

Model Validation: Summary

- Model Fit
- Parameters respond to relevant manipulations
- Parameters correlate with relevant criteria

2.3 Model Application

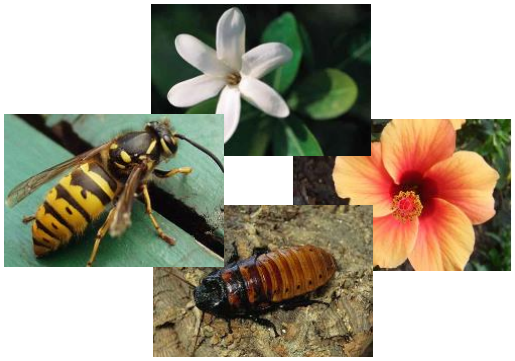
- Study 5: Modality Effects
- Study 6: Insect-Nonword IAT

Study 5: Modality Effects

(Meissner & Rothermund, 2015a)

orchid … tulip
cockroach flea

flower-insect IAT

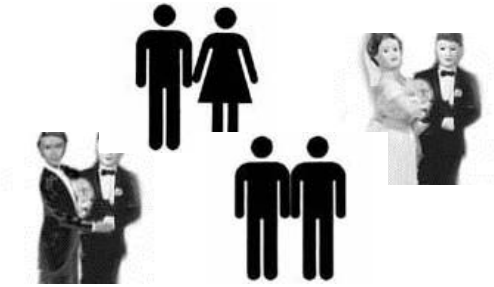


Matthew … Terryl
Leroy Adam

Black-White IAT

gay … married
straight lesbian

sexuality IAT



Material from Nosek et al., 2007

Study 5: Modality Effects

(Meissner & Rothermund, 2015a)

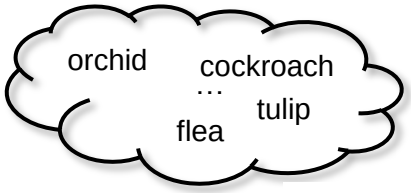
- Pictorial targets produce smaller IAT scores than verbal targets.
  (e.g., Chang & Mitchell, 2011; Foroni & Bel-Bahar, 2010; Nosek, Banaji, & Greenwald, 2002)

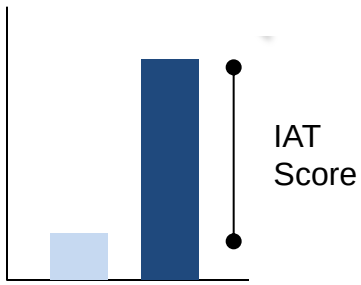
Pictures activate less extreme attitudes than words???

Recoding & Modality Effects

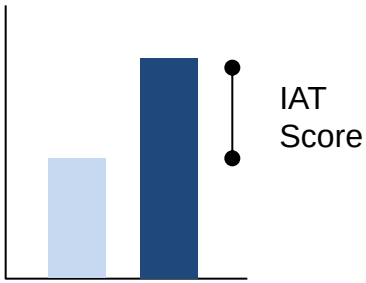
(Meissner & Rothermund, 2015a)

Verbal Targets





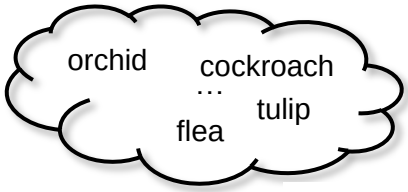
Pictorial Targets

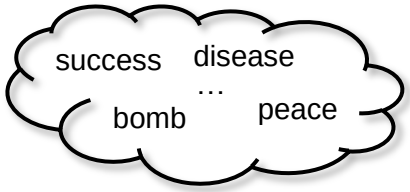


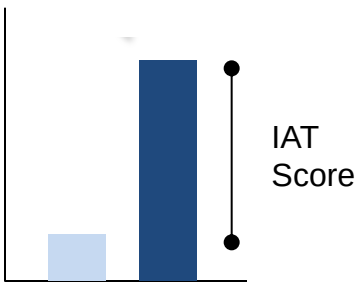
Recoding & Modality Effects

(Meissner & Rothermund, 2015a)

Verbal Targets

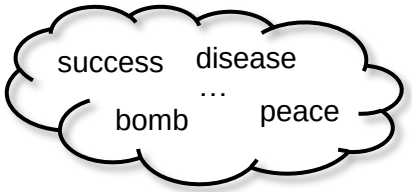


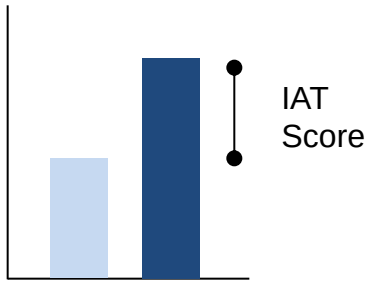




Confound

Pictorial Targets





Recoding & Modality Effects

(Meissner & Rothermund, 2015a)

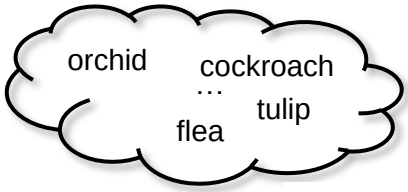
Modality Match

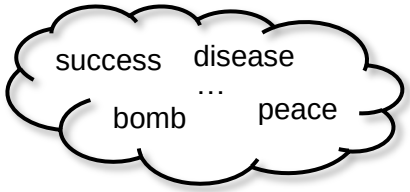
Verbal Targets

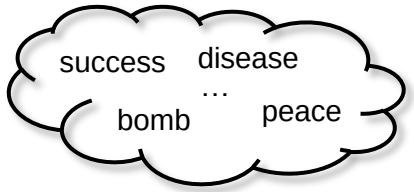
Confound

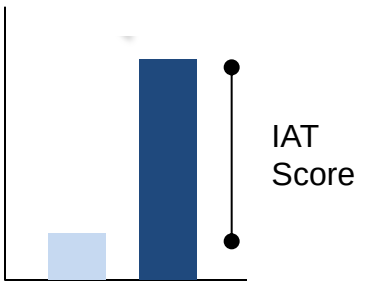
Modality Mismatch

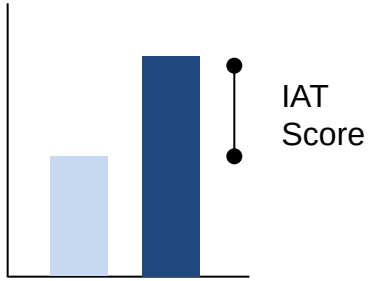
Pictorial Targets









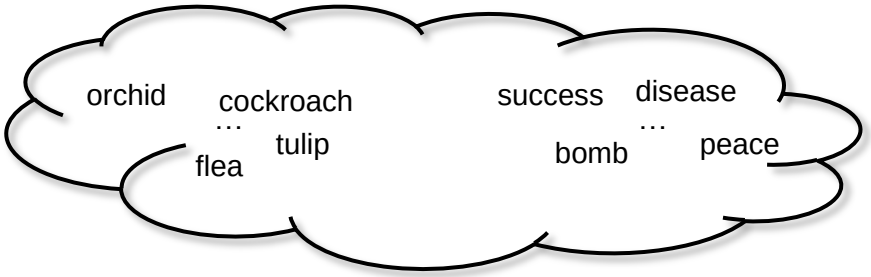


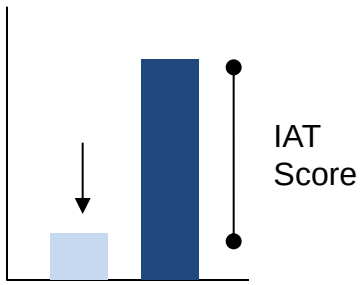
Recoding & Modality Match Effects

(Meissner & Rothermund, 2015a)

Modality Match

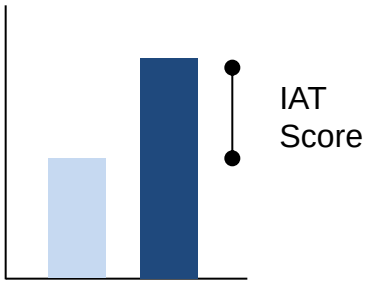
Verbal Targets





Modality Mismatch

Pictorial Targets



Study 5: Modality Effects

(Meissner & Rothermund, 2015a)

- flower-insect IAT
  (*N* = 80)

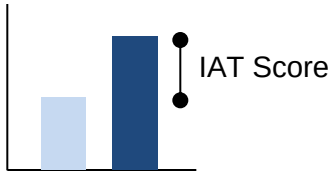
Target Modality
between-subjects

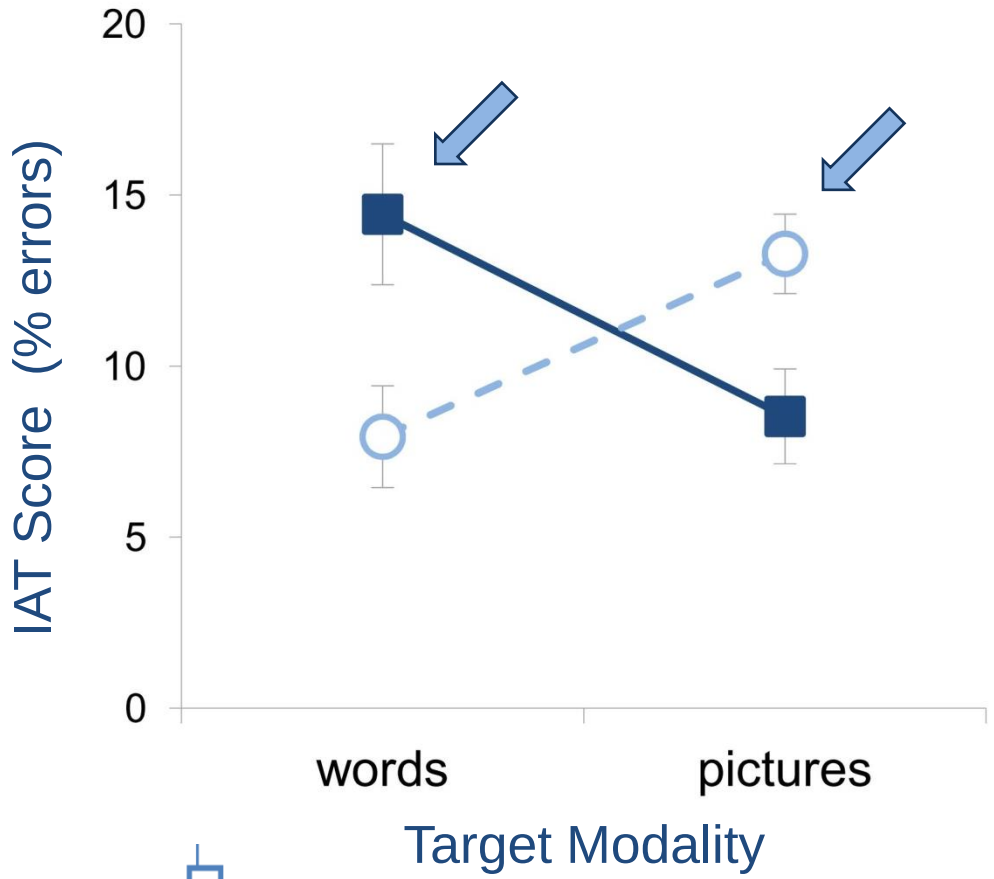
Attibute Modality
between-subjects

Match	Mismatch
Mismatch	Match

Study 5: Modality Effects

(Meissner & Rothermund, 2015a)





Attribute Modality

words

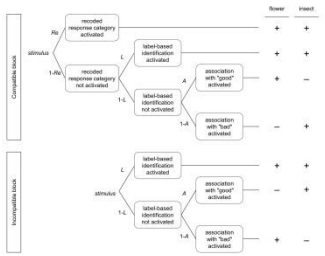
pictures

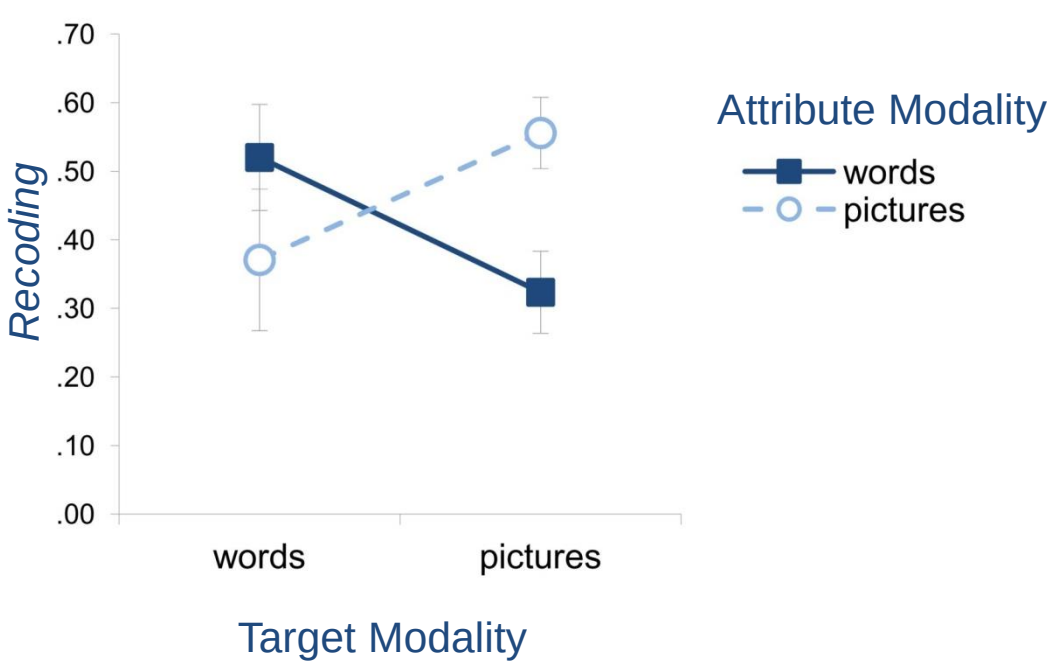
Attribute Modality x Target Modality
$F(1, 76) = 13.06$, $p < .001$, $\eta_p^2 = .15$

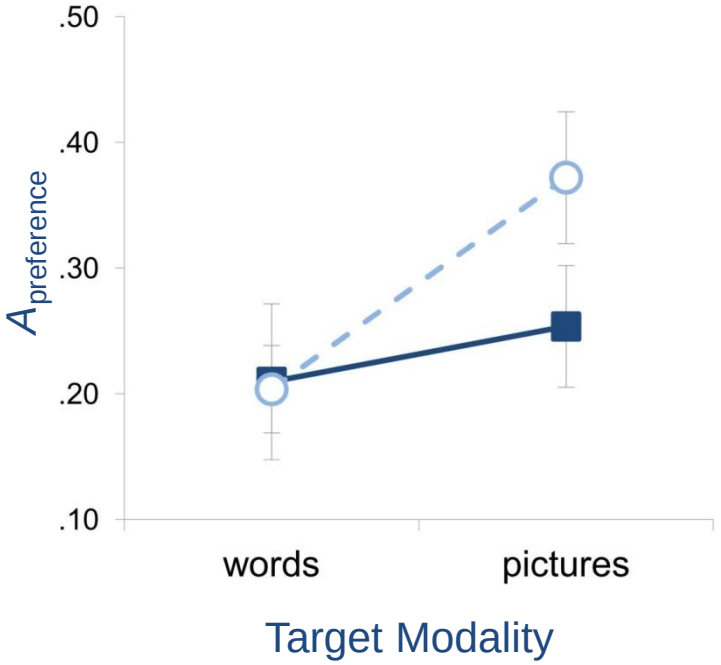
Modality Match Effect

Study 5: Modality Effects

(Meissner & Rothermund, 2015a)







Modality Match Effect

$F(1, 76) = 6.35$, $p = .014$, $\eta_p^2 = .08$

–

$F(1, 76) = 1.52$, $p = .221$, $\eta_p^2 = .02$

HE *Target Modality*, $F(1, 76) = 4.45$, $p = .038$, $\eta_p^2 = .06$

Study 5: Modality Effects

(Meissner & Rothermund, 2015a)

$IAT\ score_{pictures} < IAT\ score_{words}$

- The *modality effect* is actually a modality match effect
- … and can be attributed to recoding processes rather than associations.

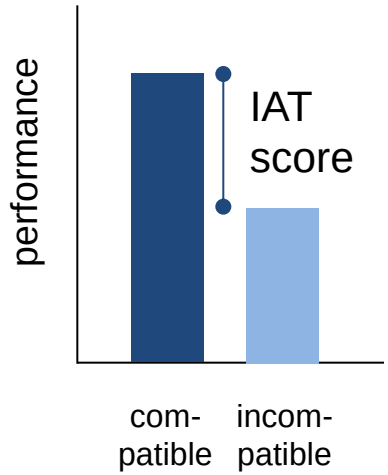
- The associative preference is even larger for pictorial compared to verbal targets!

Study 6: Insect-Nonword IAT

(Meissner & Rothermund, 2015b; cf. Brendl, Markman, & Messner, 2001)

Compatible Block

negative	positive
insect	**nonword**



Incompatible Block

negative	positive
nonword	insect

Insects are preferred over neutral nonwords?

Task recoding in the incompatible block?

(Chang & Mitchell, 2011; Rothermund & Wentura, 2004)

Study 6: Insect-Nonword IAT

(Meissner & Rothermund, 2015b)

- ReAL model analyses revealed that…
  - The task was recoded in the incompatible block.
    $Re > 0$, $\Delta G^2(1) = 9.54$, $p = .002$
  - Nonwords were neutral.
    $A_{nonword} = .5$, $\Delta G^2(1) = 2.73$, $p = .098$
  - Insects actually triggered negative associations.
    $A_{insect} < .5$, $\Delta G^2(1) = 23.61$, $p < .001$

Model Application: Summary

- The IAT score is not a pure measure of evaluative associations. Task recoding is an important confound.
- Using the ReAL Model as an analysis tool provides insights that could not have been uncovered with traditional scoring procedures.

However, there is more than just one MPT model for the IAT!

3. Different models for different research questions

Forget about recoding, just for a minute.

The Quad Model

(Conrey, Sherman, Gawronski, Hugenberg, & Groom, 2005)

- Consider this example:

Black-White IAT scores increase with age.

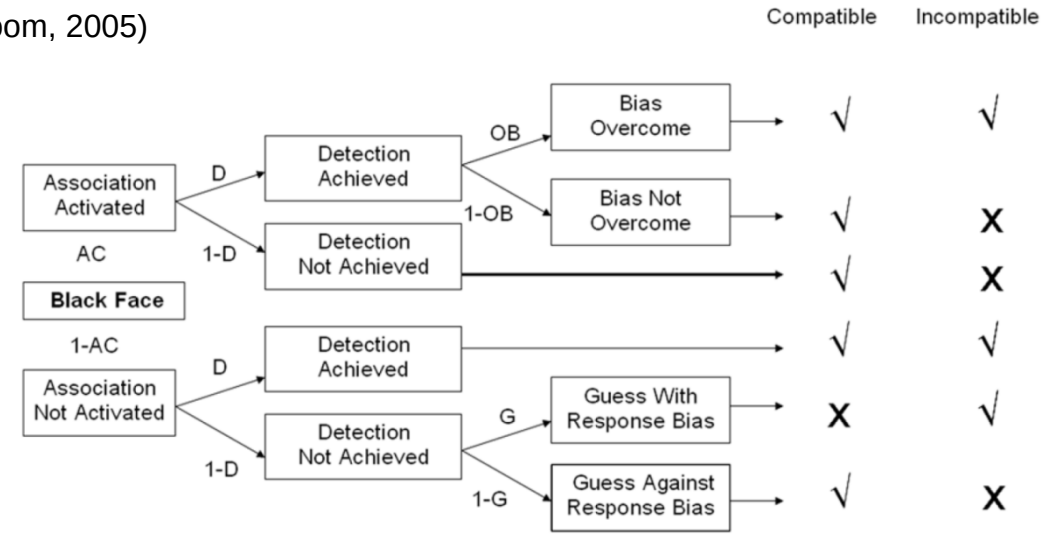
Older adults are more prejudiced.

No, attitudes remain stable. It is only the capacity to *inhibit* those attitudes that decreases over the lifespan.

(Gonsalkorale, Sherman, & Klauer, 2009)

The Quad Model

(Conrey, Sherman, Gawronski, Hugenberg, & Groom, 2005)



- The Quad Model disentangles the activation and the inhibition of attitudes.

- Model parameters
  - ***AC*** Activation of associations ($AC_{flower/pos}$, $AC_{insect/neg}$)
  - ***OB*** Overcoming bias (= inhibition)
  - ***D*** Detecting the correct response
  - ***G*** Guessing

Quad vs. ReAL Model

- Both can be applied to IAT data.
- Both claim to reflect the processes involved in the IAT.
- But they differ considerably with regard to parameters and model structure.

➡ How to decide?

- Research interest
- Model fit and complexity (AIC,BIC,FIA…)
- Parameter validity

Quad vs. ReAL Model

Research Interest

- … have different objectives and strengths.

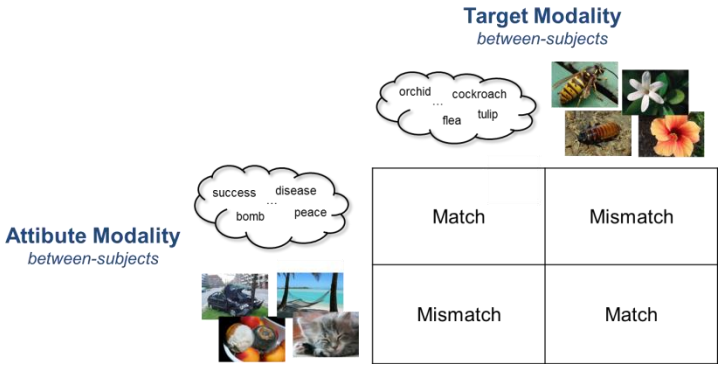
- Quad Model
  - Dissociates activation & inhibition of associations

- ReAL Model
  - Dissociaties associations & recoding
  - Measures associations even if both attitude objects are evaluated equally

= 0

Quad vs. ReAL Model

Model Fit and Model Complexity



	ReAL	Quad
ΔAIC	-3.69	0.65
ΔBIC	-26.30	-6.89
cFIA	11.47	9.31
FIA	159.56	166.44

	ReAL	Quad
% participants with ΔAIC < 0	75%	43%
% participants with ΔBIC < 0	100%	89%

$FIA_{ReAL} < FIA_{Quad}$, not only overall but actually for 89% of the participants.

Note. Due to the estimation approach (individual analysis), these are median values for the full sample of 80 participants. For each participant, we sampled 320 trials. The lower-bound trial number for an application of FIA to these data is smaller (lower-bound *N*' = 112; see Heck, Moshagen, & Erdfelder, 2014).

Use Excel-Sheet!

The ReAL model is more complex. Still, it provides the better trade-off between fit & complexity.

Quad vs. ReAL Model

Parameter Validity

- The correspondence between Quad and ReAL model parameters is not trivial.

Quad	**ReAL**
AC	*A?*
OB	*???*
D	*L?*
G	*???*

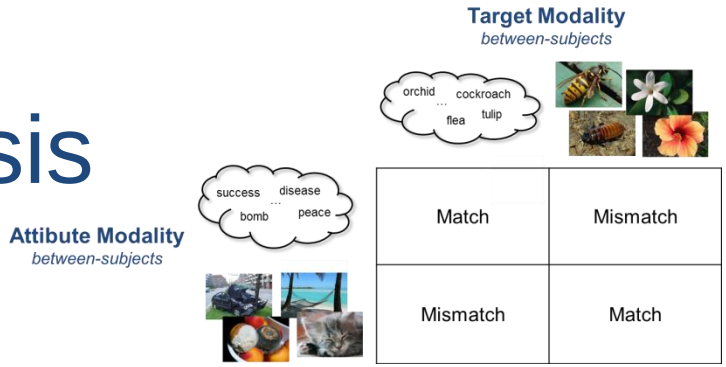
And what about *Re?*

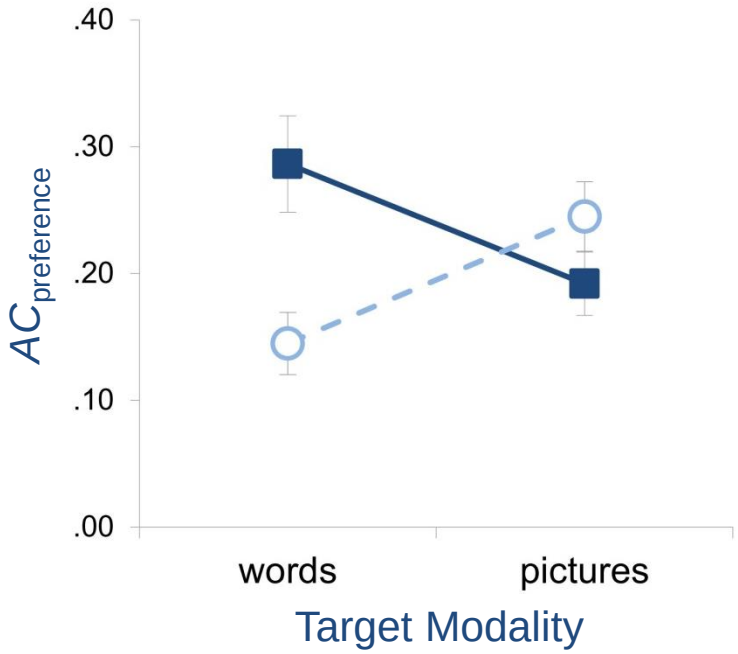
- The association parameters of the Quad model (*AC*) could be distorted by recoding.

➡ But are they?

Quad Model – Reanalysis

(cf. Meissner & Rothermund, 2015a)





Modality Match Effect

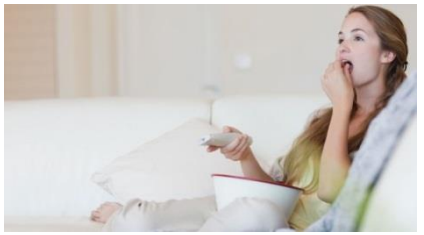
$F(1, 76) = 11.10$, $p = .001$, $\eta_p^2 = .13$

➡ So, yes, they are.

Quad Model – Reanalysis

- What about convergent validity?
  (Meissner & Rothermund, unpublished)
  - ReAL Model (*A*): $r = .25^{*}$
  - Quad Model (*AC*): $r = .09$

- … and predictive validity?
  (Meissner & Rothermund, 2013)
  - ReAL Model (*A*): $r = .24^{*}$
  - Quad Model (*AC*): $r = .19^{\dagger}$



Quad vs. ReAL Model

- Although both Quad and ReAL model fit IAT data,
  …FIA suggests to prefer the ReAL model, and
  …Quad parameters probably suffer from distortions due to recoding.

Well then, the ReAL model = the real model?

- No. At least, not yet. ReAL model parameters might be distorted as well (e.g., due to inhibition). We are planning more studies to provide a fair model comparison.

And until then?

- Both models have their strengths. So, a model should be chosen depending on the researchers' main interest.

Discussion

*Re*lated ideas?

*A*ny questions?

*L*argely confused?

Thank you.

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